Name: Key

Chemistry 129.03 Spring 2011

General Chemistry

Examination #2:

Equations, constants and periodic table are provided.

You may use a calculator.

Show all your work!

page 1: _____/13

page 2: _____/12

page 3: _____/12

page 4: _____/16

page 5: _____/15

page 6: _____/12

page 7: _____/12

page 8: _____/8

Bonus: _____/2

Total: _____/100

1. (10 pts.) Determine the oxidation numbers of each element in each reactant and product the following reaction:

$$PbS_{(s)} + 4\,H_2O_{2\,(aq)} \rightarrow PbSO_{4\,(s)} + 4\,H_2O_{(l)}$$

Reactants		Products	
Element	Oxidation Number	Element	Oxidation Number
Pb	+2	Pb	+2
S	−2	S	+6
H	+1	H	+1
O	−1	O (in $PbSO_4$)	−2
		O (H_2O)	−2

S : −2 → 6

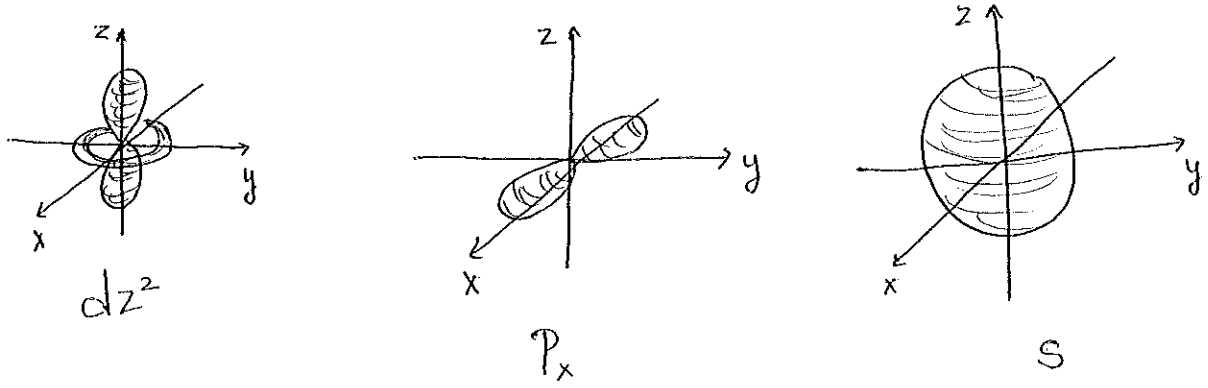
O : −1 → −2

Identify the elements being reduced and oxidized.

Oxidized S

Reduced O

2. (i) (3 pts) Make a sketch of the shape and orientation of the dz^2, p_x and s orbitals.



(ii) (3 pts.) Give the n, and l values and the number of orbitals for the **3d** subshell

$n = 3$

$l = 2$

$m_l = -2, -1, 0, 1, 2$

5 orbitals

(iii) (2 pts) How many electrons can have each of the following quantum numbers?

$n = 2, l = 1, m_l = 0$ ____2____

$n = 5, l = 2, m_s = ½$ ____5____

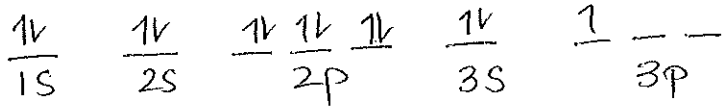
3. (7 pts) (i) Write the **full** electron configuration for **Se.** → 34 e⁻s

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$

(ii) Draw the **orbital diagram** showing number of valence electrons and unpaired electrons for **Al**.

↓

13e⁻



(iii) Identify the element with the following condensed electron configuration: **[Ne] $3s^2\ 3p^3$**

Phosphorus

↓

15 e⁻s.

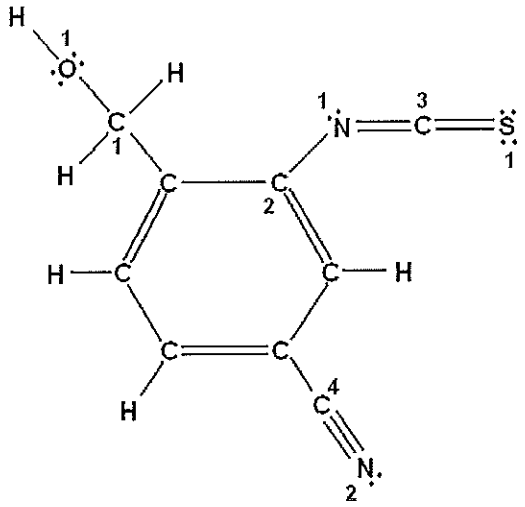
(iv) Arrange the following elements in order of **increasing** atomic radius: Cs, Ga, O, Tl, P, Ba.

O < P < Ga < Tl < Ba < Cs

(v) Arrange the following elements in order of **increasing** ionization energy: As, Sn, Sr, F, Ne.

Sr < Sn < As < F < Ne

4. (i) (10 pts) Consider the structure shown below. How many pi bonds are present? How many sigma bonds? What is the hybridization of **numbered** C, N, O and S atoms?



7 pi bonds

19 sigma bonds

N_1: sp^2

N_2: sp

C_1: sp^3

C_2: sp^2

C_3: sp

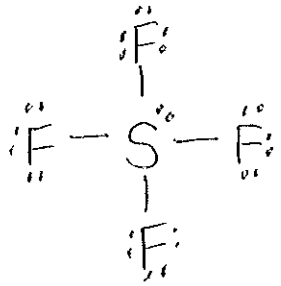
C_4: sp

O_1: sp^3

S_1: sp^2

(ii) (2 pts.) Draw the Lewis structure of SF_4 and determine the hybridization of the central atom.

↳ 34e⁻



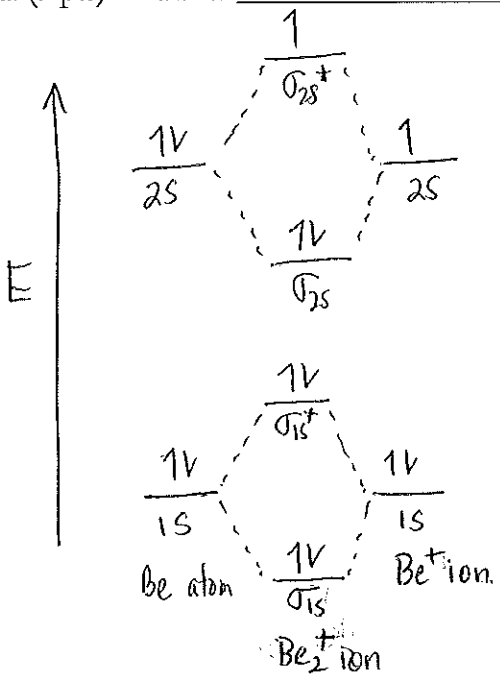
Electron Group Geometry

↳ Trigonal Bipyramida

Hybridization: sp^3d

5. (12 pts.) Consider the Be_2^+ ion.

a. (9 pts) Draw its molecular orbital energy-level diagram. What is the electron configuration of Be_2^+?



Electron Configuration:

↳ Be_2^{2+} : $\sigma_{1s}^2\ \sigma_{1s}^{*2}\ \sigma_{2s}^2\ \sigma_{2s}^{*1}$

b. (3 pts) Determine its bond order. Is Be_2^+ paramagnetic or diamagnetic? Will Be_2^+ be stable?

B.O = $\frac{1}{2}(4-3) = \frac{1}{2}$

Bond order > 0, Be_2^{2+} is stable.

Be_2^+ has one unpaired electron ⇒ it is paramagnetic.

6. (4 pts.) Choose the correct expression for K_C for the following reaction. Is the equilibrium heterogeneous or homogeneous?

$$4\ CuO_{(s)} + CH_{4\,(g)} \leftrightarrow CO_{2\,(g)} + 4\ Cu_{(s)} + 2\ H_2O_{(g)}$$

a. $K_C = \dfrac{[CH_4]}{[CO_2][H_2O]^2}$, homogeneous

b. $K_C = \dfrac{[CO_2][Cu][H_2O]^2}{[CuO]^4\,[CH_4]}$, heterogeneous

c. $K_C = \dfrac{[CuO]^4\,[CH_4]}{[CO_2][Cu][H_2O]^2}$, homogeneous

(d.) $K_C = \dfrac{[CO_2][H_2O]^2}{[CH_4]}$, heterogeneous

e. $K_C = \dfrac{[CO_2]\,[H_2O]^2}{[CuO]^4\,[CH_4]}$, heterogeneous

7. (15 pts.) Consider the following reaction.

$$CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2(g)} + H_{2(g)} \qquad K_C = 1.56$$

a. (8 pts.)A reaction mixture at 900 K initially contains [CO] = 2.00 M and [H_2O] = 2.00 M. Determine the equilibrium concentrations of CO, H_2O, CO_2, and H_2.

$$K_C = \frac{[CO_2][H_2]}{[CO][H_2O]} = 1.56$$

	[CO]	[H_2O]	[CO_2]	[H_2]
initial	2.00	2.00	0.00	0.00
change	$-x$	$-x$	x	x
equil.	$2.00-x$	$2.00-x$	x	x

$$\frac{(x)(x)}{(2.00-x)(2.00-x)} = 1.56$$

$$\frac{x}{2.00-x} = \sqrt{1.56}$$

$$x = (2.00)(\sqrt{1.56}) - (x)(\sqrt{1.56})$$

$$x = 1.11\,M$$

$[CO] = [H_2O] = 2.00\,M - 1.11\,M = \underline{0.89\,M}$

$[CO_2] = [H_2] = x = \underline{1.11\,M}$

b. (3 pts.) What reaction is favored? Reverse (reactants) or forward (products)? Why?

$K > 1$ ∴ Forward reaction is favored. (products)

c. (4 pts.) Find K_p for this reaction.

$$K_p = K_C(RT)^{\Delta n} = 1.56\left(0.0821\ \frac{L\cdot atm}{mol\cdot K} \times 900K\right)^0 = \underline{1.56}$$

$\Delta n = (2) - (2) = 0$

8. (6 pts.) Find K_C for the following reaction:

$$2\,NO_{2(g)} \leftrightarrow N_{2(g)} + 2\,O_{2(g)} \qquad K_C = ? \qquad (1)$$

Use the following data to find the unknown K_C.

$$\tfrac{1}{2}\,N_{2(g)} + \tfrac{1}{2}\,O_{2(g)} \leftrightarrow NO_{(g)} \qquad K_C = 4.8 \times 10^{-10} \qquad (2)$$

$$2\,NO_{(g)} + O_{2(g)} \leftrightarrow 2\,NO_{2(g)} \qquad K_C = 9.1 \times 10^{4} \qquad (3)$$

$2\,NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)}$ $\qquad K_2 = \left(\frac{1}{4.8 \times 10^{-10}}\right)^2$

$2\,NO_{2(g)} \rightleftharpoons 2\,NO_{(g)} + O_{2(g)}$ $\qquad K_3 = \frac{1}{9.1 \times 10^{4}}$

$2\,NO_{2(g)} \rightleftharpoons N_{2(g)} + 2\,O_{2(g)}$

$$K_1 = K_2 \times K_3 = \left(\frac{1}{4.8 \times 10^{-10}}\right)^2 \left(\frac{1}{9.1 \times 10^{4}}\right) = 4.8 \times 10^{13}$$

9. (6 pts) The following reaction is endothermic.

$$q + C_{(s)} + H_2O_{(g)} \leftrightarrow CO_{(g)} + H_{2(g)}$$

1 mol gas $\qquad$ 2 mol gas

Predict the effect (shift right, shift left, or no effect) of the following:

a. Adding more H_2 to the reaction mixture - shifts left
b. Removing some C from the reaction mixture - no effect
c. Increasing the temperature of the reaction mixture - shifts right
d. Increasing the volume of the reaction mixture - shifts right
e. Adding a catalyst to the reaction mixture - no effect
f. Removing some H_2O from the reaction mixture - shifts left

10. (4 pts) Consider the following reaction at 400 K :

$$Br_{2\,(g)} + Cl_{2\,(g)} \leftrightarrow 2\,BrCl_{(g)} \qquad K_C = 7.0$$

A closed vessel at 400K is charged with 1.00 M of Br_2, 1.00 M of Cl_2, and 2.00 M of BrCl. Use Q_C to determine which statement is true.

a. The equilibrium concentrations of Br_2, Cl_2, and BrCl will be the same as the initial values.

b. The equilibrium concentration of Br_2 will be greater than 1.00 M.

(c.) The equilibrium concentration of BrCl will be greater than 2.00 M.

d. The reaction will go to completion since there are equal amounts of Br_2 and Cl_2.

$$Q_c = \frac{[BrCl]^2}{[Br_2][Cl_2]} = \frac{(2.00)^2}{(1.00)(1.00)} = 4.00$$

$$Q_c < K_c$$

11. (8 pts) In each equation label the acids, bases, conjugate acids, and conjugate bases.

(a) $NH_4^+{}_{(aq)} + CN^-{}_{(aq)} \leftrightarrow NH_{3\,(aq)} + HCN_{(aq)}$

acid — base — conj base — conj. acid

(b) $H_2O_{(l)} + HS^-{}_{(aq)} \leftrightarrow OH^-{}_{(aq)} + H_2S_{(aq)}$

acid — base — conj. base — conj. acid.

12. (i) (2 pts) If $Ba(OH)_2$ is added to water, how does the $[H_3O^+]$ change? How does the pH change?

$Ba(OH)_{2\,(aq)} \longrightarrow Ba^{2+}_{(aq)} + 2\,OH^-_{(aq)}$

$[OH^-]$ increases $\Rightarrow$ $[H_3O^+]$ decreases $\Rightarrow$ higher pH

Basic solution.

(ii) (6 pts) A commonly available window-cleaning solution has $[OH^-] = 1.9 \times 10^{-6}$ M. Determine the $[H_3O^+]$, pH and pOH of this solution stored. Is the solution basic or acidic?

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1.9 \times 10^{-6}} = 5.3 \times 10^{-9}\ M$$

$$pH = -\log [H_3O^+] = -\log(5.3 \times 10^{-9}) = 8.28$$

$$pOH = -\log [OH^-] = -\log(1.9 \times 10^{-6}) = 5.72$$

Solution is basic.

Bonus:
Class Attendance on March 18th. (2 pts.)

Equations and Constants

Kelvin = °C + 273.15

$K_p = K_C(RT)^{\Delta n}$

$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ (at 25 °C)

pH = -log$[H_3O^+]$

pOH = -log$[OH^-]$

pH + POH = 14.00 (at 25 °C)

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$R = 0.0821 \frac{L.atm}{mol.K}$$